SECTION 2.6

THERMAL

2.6 VACUUM, THERMAL, AND HUMIDITY VERIFICATION REQUIREMENTS

The vacuum, thermal, and humidity requirements herein apply to STS and ELV payloads (spacecraft). An appropriate set of tests and analyses shall be selected to demonstrate the following payload or payload equipment capabilities.

a. The payload shall perform satisfactorily within the vacuum and thermal mission limits (including launch and return as applicable).

b. The thermal design and the thermal control system shall maintain the affected hardware within the established mission thermal limits during planned mission phases.

c. The hardware shall withstand, as necessary, the temperature and humidity conditions of transportation, storage, the orbiter cargo bay, and the orbiter manned spaces.

d. The quality of workmanship and materials of the hardware shall be sufficient to pass thermal cycle test screening in vacuum, or under ambient pressure if appropriate.

2.6.l Summary of Requirements

Table 2.6-1 summarizes the tests and analyses that collectively will fulfill the general requirements of 2.6. Tests noted in the table may require supporting analyses. The order in which tests or analyses are conducted shall be determined by the project and set down in the environmental verification plan, specification, and procedures (2.1.1.1.1 and 2.1.1.4). It is recommended, however, that mechanical testing occur before thermal testing at the systems level.

Payloads mounted in pressurized compartments of the orbiter need not be qualified for the vacuum environment, but the thermal cycling requirements of paragraph 2.6.2 do apply. These payloads must also be qualified for proper thermal performance.

The thermal cycle fatigue life test requirements of 2.4.2.1 also apply for hardware (e.g., solar arrays) susceptible to thermally induced mechanical fatigue.

The qualification and acceptance thermal-vacuum verification programs are the same except that a 10°C temperature margin is added in the thermal-vacuum test to qualify prototype or protoflight hardware.

2.6.2 Thermal-Vacuum Qualification

The thermal-vacuum qualification program shall ensure that the payload operates satisfactorily in a simulated space environment more severe than expected during the mission.

2.6.2.l Applicability - All flight hardware shall be subjected to thermal-vacuum testing in order to demonstrate satisfactory operation in modes representative of mission functions at the nominal operating temperatures, at temperatures in excess of the extremes predicted for the mission, and during temperature transitions. The tests shall demonstrate satisfactory operation over the range of possible flight voltages. In addition, hot and cold turn-on shall be demonstrated where applicable.

TABLE 2.6-1

VACUUM, THERMAL, AND HUMIDITY REQUIREMENTS

Requirement	Payload or Highest Practicable Level of Assembly	Subsystem including Instruments	Unit/ Component
Thermal-Vacuum[1,2]	T	T	T
Thermal Balance[1,3]	T and A	T,A	T,A
Temperature-Humidity[3] (Manned Spaces)	T/A	T/A	T,A
Temperature-Humidity[4] (Descent & Landing)	T/A	T/A	T,A
Temperature-Humidity[5] (Transportation & Storage)	A	A	A
Leakage[6]	T	T	T

1 Applies to hardware carried in the unpressurized cargo bay of the orbiter, and to ELV-launched hardware.

2 Temperature cycling at ambient pressure may be substituted for thermal-vacuum temperature cycling if it can be shown analytically to be acceptable.

3 Applies to flight hardware located in pressurized area which support payloads in the cargo bay.

4 Applies to hardware that must retain a specified performance after return from orbit and is carried in the unpressurized cargo bay.

5 Consideration should be given to environmental control of the enclosure.

6 Hardware that passes this test at a lower level of assembly need not be retested at a higher level unless there is reason to suspect its integrity.

T = Test required.

A = Analysis required; tests may be required to substantiate the analysis.

T/A = Test required if analysis indicates possible condensation.

T,A = Test is not required at all levels of assembly if analysis verification is established for non-tested elements.

Note: Card level thermal analysis is required to insure temperature limits, for example, junction temperatures, are not exceeded.

Spare components shall undergo a test program in which the number of thermal cycles is equivalent to the total number of cycles other flight components are subjected to at the component, subsystem, and payload levels of assembly. As a minimum, spare components shall be subjected to eight thermal cycles prior to integration onto payload/spacecraft. Likewise, the durations of the tests at the upper and lower temperatures shall be the same as those for flight components.

Redundant components shall be exercised sufficiently during the test program, including cold and hot starts, to verify proper orbital operations. Testing to validate cross-strapping shall also be performed if applicable. The method of conducting the tests shall be described in the environmental verification test specification and procedures (2.1.1.1.1 and 2.1.1.4).

Consideration should be given to conducting the thermal balance verification test in conjunction with the thermal-vacuum test program. A combined test is often technically and economically advantageous. It must, however, satisfy the requirements of both tests. The approach that is chosen shall be described in the environmental verification specification and procedures.

2.6.2.2 Special Considerations -

a. Unrealistic Failure Modes - Care shall be taken during the test to prevent unrealistic environmental conditions that could induce test failure modes. For instance, maximum rates of temperature changes shall not exceed acceptable limits. The limits are based on hardware characteristics or orbital predictions.

b. Avoiding Contamination - Elements of a test item can be sensitive to contamination arising from test operations or from the test item itself. If the test item contains sensitive elements, the test chamber and all test support equipment shall be examined and certified prior to placement of the item in the chamber to ensure that it is not a significant source of contamination. Particular care shall be taken that potential contaminants emanating from the test item are not masked by contaminants from the chamber or the test equipment. Chamber bakeout and certification may be necessary for contamination sensitive hardware.

The level of contamination present during thermal vacuum testing should be monitored using, as a minimum, a Temperature-controlled Quartz Crystal Microbalance (TQCM) to measure the accretion rate and a cold finger to obtain a measure of the content and relative amount of the contamination. The use of additional contamination monitors such as a Residual Gas Analyzer (RGA), mirrors, and chamber wipes shall also be considered. When using TQCMs, RGAs, or mirrors, the locations of the sensors must be carefully selected so that they will adequately measure outgassing from the desired source.

Transitions from cold to hot conditions increase contamination hazards because material that has accreted on the chamber walls may evaporate and deposit on the relatively cool test item. Transitions shall be conducted at rates sufficiently slow to prevent that from occurring. Testing shall start with a hot soak and end with a hot soak to minimize this risk. However, if it is necessary that the last exposure be a cold one, the test procedure shall include a phase to warm the test item before the chamber is returned to ambient conditions so that the item will remain the warmest in the test chamber, thus decreasing the likelihood of its contamination during thecritical period. In all cases, every effort should be made to keep the test article warmer than its surroundings during testing.

2.6.2.3 Level of Testing - The demonstrations described below apply to component, subsystem/instrument, and payload level tests. If it is impracticable to test an entire integrated payload, the test may be conducted at the highest practicable level of assembly and ancillary testing and analyses shall be conducted to verify the flightworthiness of the integrated payload. In cases where testing is compromised, for example the inability to drive temperatures of the all-up assembly to the qualification limits, testing at lower levels of assembly may be warranted.

2.6.2.4 Test Parameters - The following parameters define key environmental conditions of the test:

a. Thermal Margins - Thermal margins shall be established to provide allowances to compensate for uncertainties in the thermal parameters and to induce stress conditions to detect unsatisfactory performance that would not otherwise be uncovered before flight.

When a thermal balance test precedes the thermal-vacuum test, results from that test shall be used to refine the thermal-vacuum test criteria, presuming that the thermal analysis model has been test verified.

The maximum and minimum temperatures to be imposed during the thermal-vacuum test shall be based on either program requirements or predicted temperatures derived analytically, using a verified model, that each component will undergo during the mission, and shall represent a temperature range, including margins, large enough to induce workmanship stressing during temperature cycling.

A temperature margin of no less than 10°C above the predicted maximum operating conditions and 10°C below the minimum operating conditions (and if appropriate, nonoperating conditions) shall be used in establishing test temperatures. Where the temperature of an area is controlled by a verified active thermal control system, the margin may be reduced to no less than 5°C. Verification may be shown by establishing that the heater will be on no more than 70 percent of the time at the lower operating limit with worst case cold environment (cold environmental fluxes, low biased power, minimum orbit average voltage, cold case thermal properties, etc.) thereby providing a positive heater control margin of 30 percent. This demonstration must be accomplished by test.

Test temperatures for a thermal vacuum soak shall be based on the temperatures at selected locations or average temperature of a group of locations. The locations shall be selected in accordance with an assessment to ensure that components or critical parts of the payload achieve the desired temperature for the required time during the testing cycle. As an example, the temperature sensors shall be attached to the component base plate or to the heat sink on which the component is mounted. Temperature soaks and dwells shall begin when the “control” temperature is within ± 2° C of the proposed test temperature.

b. Temperature Cycling - Cycling between temperature extremes has the purpose of checking performance at other than stabilized conditions and of causing temperature gradient shifts, thus inducing stresses intended to uncover incipient problems. The minimum number of thermal-vacuum temperature cycles for the payload, subsystem/instrument, and component levels of assembly are as follows:

1. Payload/Spacecraft - Four (4) thermal-vacuum temperature cycles shall be performed at the payload level of assembly. If the expected mission temperature excursions are small (less than 10° C) or the transition times are long (greater than 72 hours), the minimum number of thermal-vacuum test cycles may be reduced to two (2) with project approval; however, in these cases the durations for the hot and cold temperature dwells shall be doubled.

2. Subsystem/Instrument - A minimum of four (4) thermal-vacuum temperature cycles shall be performed at the subsystem/instrument level of assembly. During the cycling, the hardware shall be operating and its performance shall be monitored.

3. Component/Unit - All space hardware shall be subjected to a minimum of eight (8) thermal-vacuum temperature cycles before being installed into the payload; these may include test cycles performed at the subsystem/instrument level of assembly. During the cycling, the hardware shall be operating and its performance shall be monitored.

   For components that are determined by analysis to be insensitive to vacuum effects relative to temperature levels and temperature gradients, the requirements may be satisfied by temperature cycling at normal room pressure in an air or gaseous-nitrogen environment. If this approach is used, the cycling at ambient pressure should be increased (both the temperature range and the number of cycles) to account for possible analytical uncertainties and to heighten the probability of detecting workmanship defects. It is recommended that the qualification margin of ± 10°C (in vacuum) be increased to ±15°C if testing at ambient pressure is performed. Likewise, the number of thermal cycles should be increased by fifty (50) percent if testing at ambient pressure (i.e., if 4 cycles would be performed in vacuum, then 6 cycles should be performed at ambient pressure).

   The recommended approach is to test in the expected environment (vacuum). If testing at ambient pressure is implemented, GSFC project approval is required.

c. Duration - The total test duration shall be sufficient to demonstrate performance and uncover early failures. The duration varies with the time spent at the temperature levels and with such factors as the number of mission-critical operating modes, the test item thermal inertia, and test facility characteristics. Minimum temperature dwell times are as follows:

   1. Payloads/Spacecraft - Payloads shall be exposed for a minimum of twenty-four (24) hours at each extreme of each temperature cycle. The thermal soaks must be of sufficient duration to allow time for performance tests. For small payloads (Scout class), the durations may be shortened, if appropriate, for mission simulation. For large payloads that elect to perform only two (2) thermal-vacuum cycles at the payload level of assembly, the dwell times shall be doubled to a minimum of forty-eight (48) hours.

   2. Subsystem/Instrument - Subsystems and instruments shall be exposed for a minimum of twelve (12) hours at each extreme of each temperature cycle. The thermal soaks must be of sufficient duration to allow time for performance tests.

3. Unit/Component - Components shall be exposed for a minimum of four (4) hours at each extreme of each temperature cycle.

d. Functional Test - Because of the length of time involved, it may be impracticable to conduct a comprehensive electrical functional test during thermal-vacuum verification. With project approval, a limited functional test may be substituted if satisfactory performance is demonstrated for the major mission-critical modes of operation. Otherwise, the requirements of 2.3 apply.

e. Pressure - The chamber pressure after the electrical discharge checks are conducted shall be less than 1.33×10^{-3} Pa. (1×10^{-5} torr).

f. Turn-on Demonstration - Turn-on capability shall be demonstrated under vacuum at least twice at both the low and high temperatures, as applicable. Turn-on temperatures are defined by the expected mission operations; that is, temperatures should be in slight, 2°C, excess of either safe-hold or survival conditions. The ability to function through the voltage breakdown region shall be demonstrated if applicable to mission requirements (all elements that are operational during launch).

2.6.2.5 Test Setup - The setup for the test, including any instrument stimulators, shall be reviewed to ensure that the test objectives will be achieved, and that no test induced problems are introduced. The payload test configurations shall be as described in the test plan and test procedure. The test item shall be, as nearly as practicable, in flight configuration. The components shall be thermally coated and the mounting surface shall have the same treatment as it will have during flight. Critical temperatures shall be monitored throughout the test and "alarmed" if possible. The operational modes of the payload shall be monitored in accordance with 2.3. The provisions of 2.3 apply except when modified by the considerations of 2.6.2.4 d.

2.6.2.6 Demonstration -

a. Electrical Discharge Check - Items that are electrically operational during pressure transitions shall undergo an electrical discharge check to ensure that they will not be permanently damaged from electrical discharge during the ascent and early orbital phases of the mission, or during descent and landing (if applicable). The test shall include checks for electrical discharge during the corresponding phases of the vacuum chamber operations.

b. Outgassing Phase - If the test article is contamination sensitive (or if required by the contamination control plan) an outgassing phase must be included to permit a large portion of the volatile contaminants to be removed. The outgassing phase will be incorporated into a hot exposure that will occur during thermal-vacuum testing. The test item will be cycled hot and remain at this temperature until the contamination control monitors indicate that the outgassing has decreased to an acceptable level.

c. Hot and Cold Start Demonstrations - Start-up capability shall be demonstrated to verify that the test item will turn on after exposure to the extreme temperatures that may occur in orbit. For this check, the test item may be in one of three modes: commanded-off, undervoltage-recycle, or high-voltage.

Cold Conditions - The temperature controls shall be adjusted to cause the test item to stabilize at the lower test temperature. Cold turn-on capability shall be demonstrated as required and may be conducted at the start of the cold condition. The duration of the cold phase shall be at least sufficient to permit the performance

The duration of the cold phase shall be at least sufficient to permit the performance of the functional tests with a minimum soak time of four (4) hours for components, twelve (12) hours for subsystems and instruments, and twenty-four (24) hours for payload testing.

e. Transitions - The test item shall remain in an operational mode during the transitions between temperatures so that its functioning can be monitored under a changing environment. The requirement may be suspended when turn-on of the test item is to be demonstrated after a particular transition. In certain cases, it may be possible to remove thermal insulation to expedite cool-down rates. Caution must be taken not to violate temperature limits, or to induce test failures caused by excessive gradients.

f. Hot Conditions - The temperature controls shall be adjusted to cause the test item to stabilize at the upper test temperature. Hot turn-on capability is demonstrated as required. The duration of this phase shall be at least sufficient to permit the performance of the functional tests with a minimum soak time of four (4) hours for components, twelve (12) hours for subsystems and instruments, and twenty-four (24) hours for payload testing.

g. Return to Ambient - If the mission includes a requirement for the test item to remain in an operational mode through the descent and landing phases, the test shall include a segment to verify that capability. If possible, the test article should be kept warmer than the surroundings to protect against contamination from the test facility.

2.6.2.7 Special Tests - Special tests may be required to evaluate unique features, such as a radiation cooler, or to demonstrate the performance of external devices such as solar array hinges or experiment booms that are deployed after the payload has attained orbit.

The test configuration shall reflect, as nearly as practicable, the configuration expected in flight.

When items undergoing test include unusual equipment, special care must be exercised to ensure that the equipment does not present a hazard to the test item, the facility, or personnel.

Any special tests shall be included in the environmental verification specification (1.10.2).

2.6.2.8 Trouble-Free-Performance - At least 100 trouble-free hours of functional operations at the hot conditions, and 100 trouble-free hours of functional operations at the cold conditions must be demonstrated in the thermal verification program (refer to section 2.3.4).

2.6.2.9 Acceptance Requirements - The above provisions apply for the acceptance of previously qualified hardware except that the 10°C margin may be waived.

2.6.3 Thermal Balance Qualification

The adequacy of the thermal design and the capability of the thermal control system shall be verified. It is preferable that the thermal balance test precede the thermal vacuum test so that the results of the balance test can be used to establish the temperature goals for the thermal vacuum test.

2.6.3.1 Alternative Methods - It is preferable to conduct a thermal balance test on the fully assembled payload. If that is impracticable, one of the following alternative methods may be used:

a. Test at lower levels of assembly, and compare the results with the predictions derived from the modified analytical model.

b. Test a thermally similar physical representation of the flight payload (e.g. a physical thermal model) and compare the results with predictions derived from the analytical model (modified as necessary).

If the flight equipment is not used in the tests, additional tests to verify critical thermal properties, such as thermal control coating absorptivity and emissivity, shall be conducted to demonstrate similarity between the item tested and the flight hardware.

2.6.3.2 Use of a Thermal Analytical Model - In the course of a payload program, analytical thermal models are developed of the payload, its elements, and the mission environment for the purpose of predicting the thermal performance during the mission. The models can be modified to predict the thermal performance in a known test-chamber environment. Correlation of the results of the chamber thermal balance tests with predictions derived from the modified analytical model provides a means for validating the thermal design and for improving model accuracy. Predictions derived from the modified analytical model must be based on the actual test conditions. At the same time, a thermal balance test can provide the basis for evaluating the performance of the as-built thermal control system.

2.6.3.3 Method of Thermal Simulation - A decision must be made as to the method used to simulate thermal inputs. The type of simulation to be used is generally determined by the size of the chamber, the methods available to simulate environmental conditions, and the payload. In planning the method to be used, the project test engineer should try to achieve the highest practical order of simulation; that is, the one that requires the minimum number of assumptions and calculations to determine the environmental inputs. The closer the simulation to the worst case environments, the less reliance on the thermal analytical model to verify the adequacy of the thermal design. Methods of simulation and the major assumptions for a successful test are described below:

a. Solar inputs can be simulated by mercury-xenon, xenon, or carbonarc sources and/or heaters as described below. The spectrum and uniformity of the source used to simulate the sun and planet albedo must be understood. The change in effective absorptivity caused by spectrum mismatches can be quite large; the emissivity change is quite small.

b. Planetary, or earth emissions, can be simulated with either:

(1) Skin Heaters - This is an acceptable test for simply shaped payloads. The absorbed energy from all exterior sources are simulated by the skin using I^2R heaters. The absorptivity and incident radiation are used to calculate the absorbed energy to be simulated,

(2) Heater Plates - This can be an acceptable test if the payload outer skins are not touched. The same information is needed for the plates as for the skin heaters and the exchange factor between the plates and the payload must be known. In both cases, a net balance equation considering absorptivity, emissivity, incident and rejected energies must be solved to establish accurate test conditions.

The internal power dissipated in a spacecraft or subsystem shall be measured to an accuracy of 1%. If possible, and prior to the test, the power consumption and line losses of the individual components should be measured.

2.6.3.4 Extraneous Effects - Extraneous effects such as gaseous conduction in residual atmosphere should be kept negligible by vacuum conditions in the chamber; pressures below 1.33 X 10^{-3} Pa (1 X 10^{-5} torr) are usually sufficiently low. Care shall also be taken to prevent conditions, such as test configuration-induced contamination, that cause an unrealistic degradation of the test item. Devices such as a TQCM, cold finger, RGA, mirrors, witness samples, and chamber wipes shall be included as necessary to monitor contamination.

2.6.3.5 Demonstration - The number of energy balance conditions simulated during the test shall be sufficient to verify the thermal design. (If it is necessary to verify the thermal model, a minimum of two tests are required.) The duration of the thermal balance test depends on the mission, payload design, payload operating modes, and times to reach stabilization; stabilization is generally considered to have been achieved when the control sensors change less than 0.05°C per hour, for a period of not less than six hours, and exhibit a decreasing temperature slope over that period. Alternatively, a stabilization criteria may be used where the amount of energy represented by the time rate of temperature change (and the thermal mass of the test article) is a small fraction (typically 2 to 5%) of the total energy of the test article. The exposures shall be long enough for the payload to reach stabilization so that temperature distributions in the steady-state conditions may be verified. The conditions defining temperature stabilization shall be described in the environmental verification specification.

The amount of differences allowed between predicted and measured temperatures are determined by the cognizant thermal analyst. Verification of the thermal analytical model is considered accomplished if the established criteria are met.

2.6.3.6 Acceptance Requirements - The thermal balance test may be waived, but either tests shall be conducted to verify the thermal similarity to the previously qualified hardware or sufficient temperature margins exist to preclude reverification.

2.6.4 Temperature-Humidity Verification: Manned Spaces

If the environment is such that condensation can occur, tests shall be conducted to demonstrate that the hardware can function under the severest conditions that credibly can be expected.

2.6.4.1 Applicability - The test applies to payloads that are to be located in manned spaces of the STS and to equipment placed in manned spaces for the control or support of payloads located in the unpressurized cargo bay.

2.6.4.2 Demonstration - The hardware shall be tested at temperature and relative humidity conditions at least 10°C and 10% RH beyond the limits expected during the mission. The upper humidity conditions, however, should not exceed 95% RH unless condensation can occur during the mission; in that event, tests shall be conducted to demonstrate that the hardware can function properly after (or, if applicable, during) such exposure.

Temperature cycling, duration, performance tests, and other requirements (except those related to vacuum) as described for the thermal-vacuum test (2.6.2) shall apply.

2.6.5 Temperature-Humidity Verification: Descent and Landing

Hardware that is to undergo the temperature and humidity environment of the unpressurized cargo bay and that must return from orbit with a specified performance capability (e.g. throughput or reflectivity) shall be subjected to a temperature-humidity test to verify that it can survive the environmental conditions during descent and landing without experiencing unacceptable degradation.

2.6.5.1 Special Considerations - If the test would make the hardware unflightworthy, such as by rendering thermal control surfaces ineffective, then it should not be performed on the flight item. Instead, an analysis based on tests of engineering or prototype models, or other convincing methods, may be used.

2.6.5.2 Demonstration - The test item shall be placed in a temperature-humidity chamber and a functional performance test shall be performed before the item is exposed to the test environment. If a functional performance test was conducted as part of the post-test check-out of the preceding test, those results may be sufficient.

The temperature and humidity profiles in Figure 2.6-1 set the parameters for the demonstration. The payload shall be in a configuration appropriate for the descent and landing phase.

Electrical function tests (2.3) shall be conducted after the test exposure to determine whether acceptable limits of degradation have been exceeded.

2.6.5.3 Acceptance Requirements - The above provisions apply for the acceptance of previously qualified hardware.

2.6.6 Temperature-Humidity: Transportation and Storage

Hardware that will not be maintained in a temperature-humidity environment that is controlled within acceptable limits during transportation and storage shall be subjected to a temperature-humidity test to verify satisfactory performance after (and, if applicable, during) exposure to that environment.

2.6.6.1 Applicability - The test applies to all payload equipment. It need not be conducted on equipment for which the demonstrated acceptable limits have been established during other portions of the verification program.

2.6.6.2 Demonstration - The demonstration shall be performed prior to the thermal-vacuum test. An analysis shall be made to establish the uncontrolled temperature and humidity limits to which the item will be exposed from the time of its integration at the component level through launch. The item shall be placed in a temperature-humidity chamber and electrical function tests (2.3) shall be conducted before the item is exposed to the test environment.

If an electrical function test was conducted during the post-test checkout of the preceding test, the results of that may suffice. Functional tests shall also be conducted during the test exposure if the item will be required to operate during the periods of uncontrolled environment.

The test shall include exposure of the hardware to the extremes of temperatures and humidities as follows: 10°C and 10 RH (but not greater than 95% RH) higher and lower than those predicted for the transportation and storage environments. The test item shall be exposed to each extreme for a period of six (6) hours.

Electrical function tests shall be conducted after the test exposure to demonstrate acceptable performance.

2.6.6.3 Acceptance Requirements - The above provisions apply to previously qualified hardware except that the 10°C and 10 RH margins may be waived.

2.6.7 Leakage (Integrity Verification)

Tests shall be conducted on sealed items to determine whether leakage exceeds the rate prescribed for the mission.

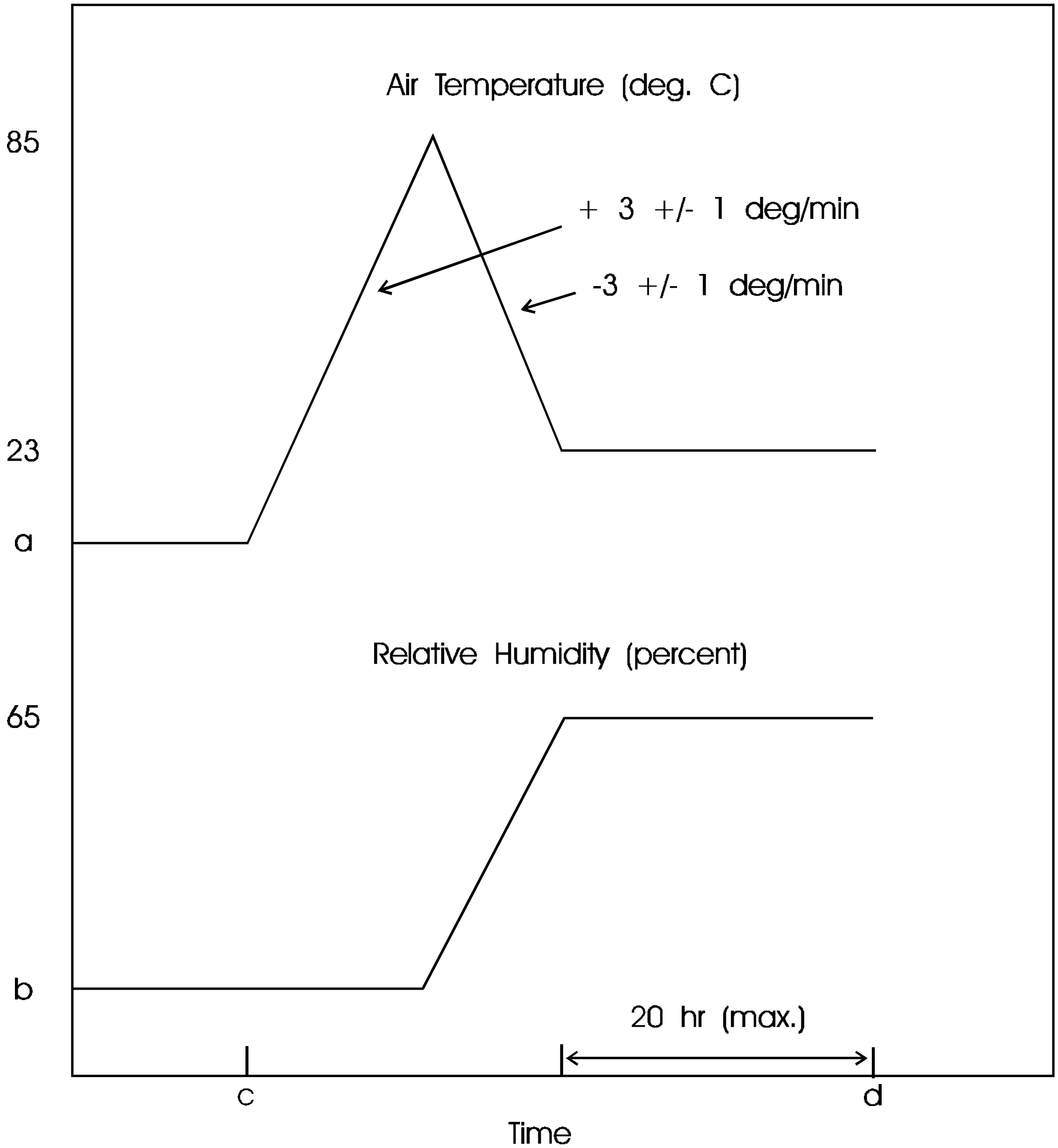
2.6.7.1 Levels of Assembly - Tests may be conducted on the component level of assembly to gain assurance that the item will function satisfactorily before tests are made at higher levels. Checks at the payload level need include only those items that have not demonstrated satisfactory performance at the lower level, are not fully assembled until the higher levels of integration, or the integrity of which is suspect.

2.6.7.2 Demonstration - Leakage rates are checked before and after stress-inducing portions of the verification program. The final check may be conducted during the final thermal-vacuum test.

A mass spectrometer may be used to detect flow out of or into a sealed item.

If dynamic seals are used, the item shall be operated during the test, otherwise operation is not required. The test should be conducted under steady-state conditions, i.e., stable pumping, pressures, temperatures, etc. If time constraints do not permit the imposition of such conditions, a special test method shall be devised.

2.6.7.3 Acceptance Requirements - The above provisions apply to the acceptance testing of previously qualified hardware.



Legend: a. = Temperature of payload at deorbit
b. = Minimum chamber relative humidity
c. = Payload temperature stabilized
d. = Functional check-out

Figure 2.6-1 Temperature-Humidity Profile for Descent and Landing Demonstration